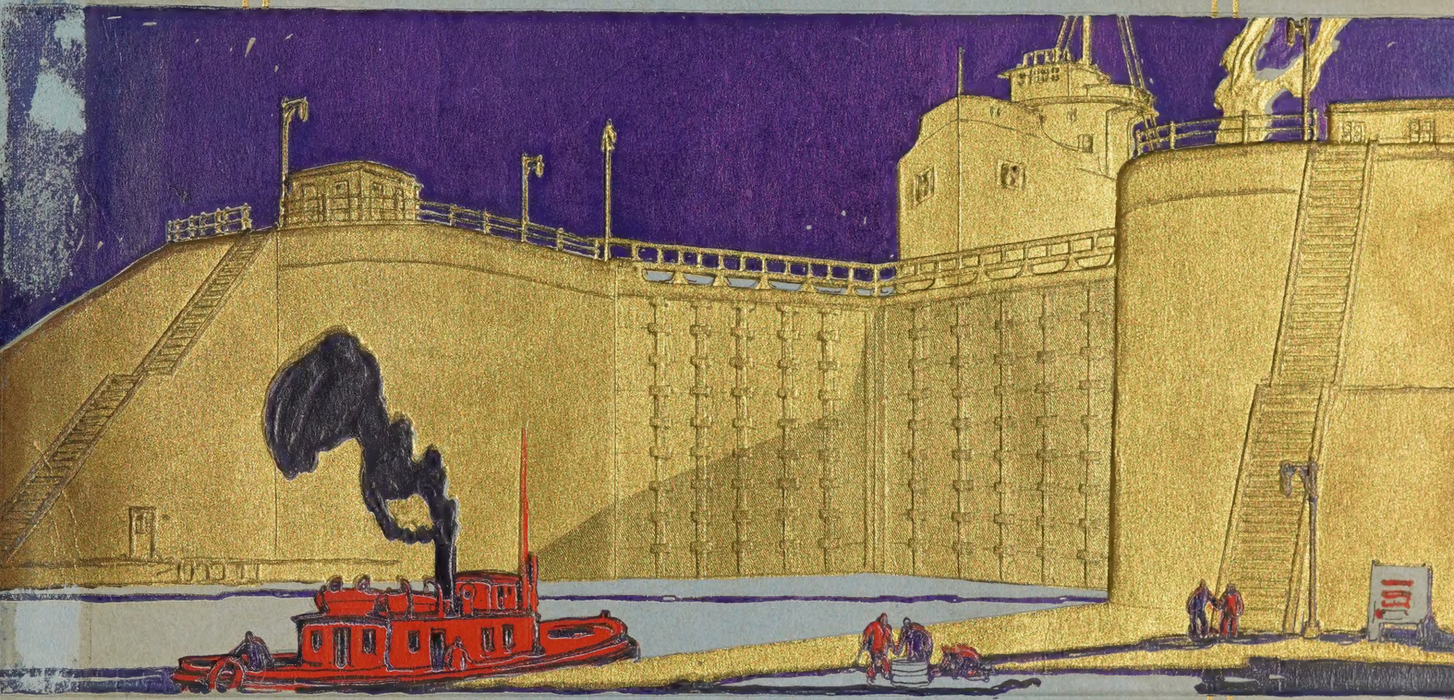
The WELLAND SHIP CANAL



NEW LINK IN THE WORLD'S GREATEST INLAND WATERWAY

Published by Authority of the Hon. Dr. R. J. Manion, M.P.
Minister of Railways and Canals

AUGUST SIXTH ~ NINETEEN THIRTY TWO

the Opening of The Welland Ship Canal

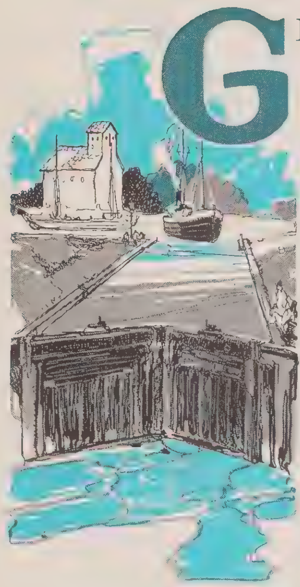
A Canadian Conception

A Canadian Achievement

First Welland Canal—Lock at St. Catharines.

THE WELLAND CANALS

Links in the World's Greatest Inland Waterway

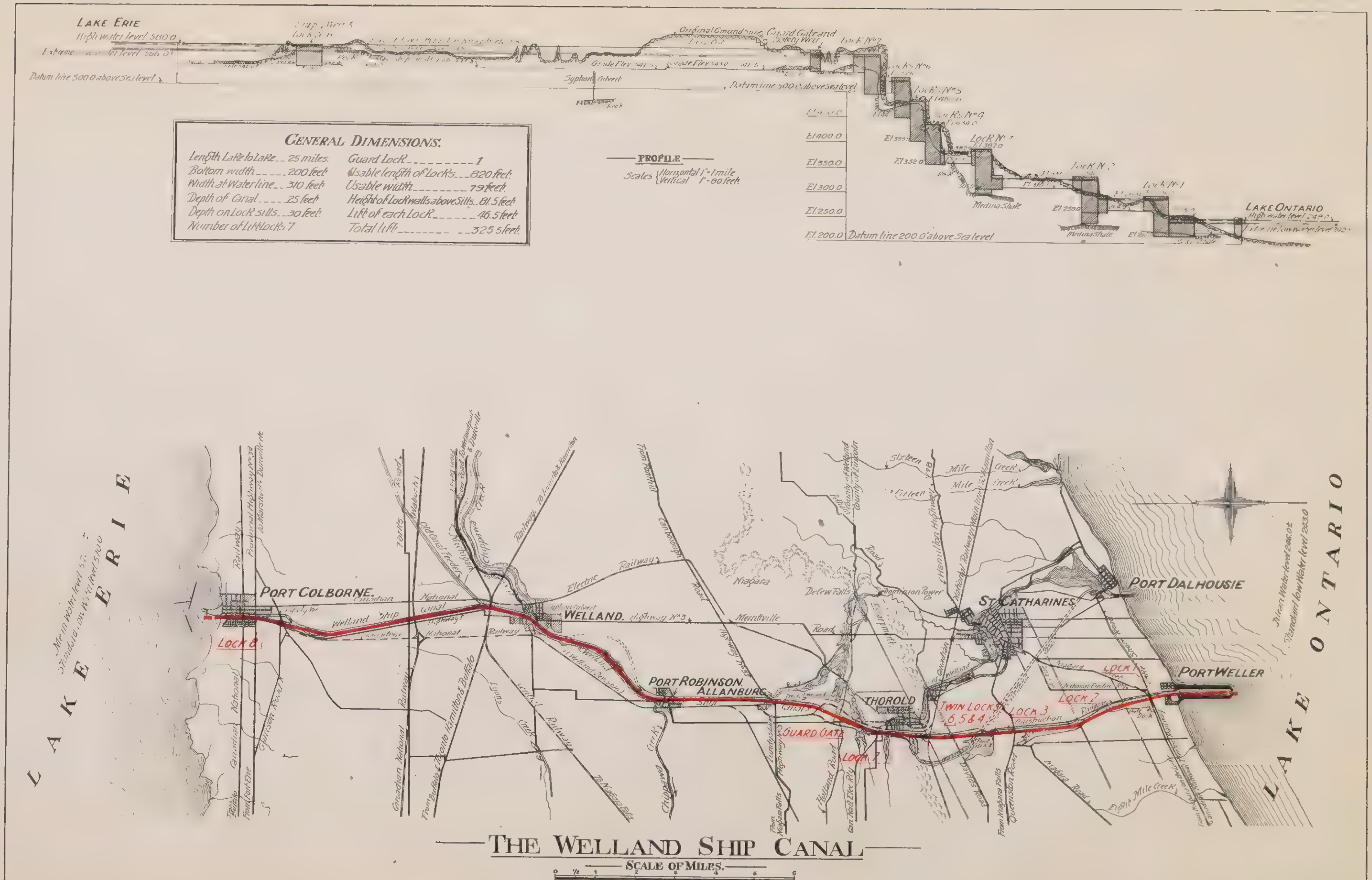


GREAT as are the advantages afforded Canada by the St. Lawrence system of lakes and rivers, they could never be fully realized were it not for the series of canals started over a hundred years ago, and gradually improved since, between the Great Lakes and Montreal, chiefly amongst them the Welland Canals connecting Lake Erie with Lake Ontario.

Champlain, La Salle, Joliette and other early explorers braved death and starvation to find a short water passage to the Orient by the St. Lawrence River and the great inland lakes of the North American Continent. Their followers were more concerned with a waterway outlet for the constantly increasing production of raw furs and other merchandise beyond the Great Lakes.

Before them stood mighty Niagara Falls, presenting an insurmountable barrier and standing as though on guard at the entrance to the Great Lakes.

Neither up nor down these falls could any craft pass and resort had to be had to the laborious task of portaging from Queenston, on the Niagara River, to Chippawa Creek. Even with the birch bark canoe carrying the minimum of baggage and supplies, this was a trying task for men of the strongest physique. When the settlement of the upper country added to the water-borne traffic and necessitated the use of larger craft, it became imperative that the Welland Canal should be constructed if the country were not to be retarded in its development.


LAKE ERIE
High water level 580.0
Datum line 500.0 above Sea level
Original Ground Surface
Guard Gate and Safety Weir
Lock No. 7
Lock No. 6
Lock No. 5
Lock No. 4
Lock No. 3
Lock No. 2
Lock No. 1
Syphon Culvert
Datum line 300.0 above Sea level
El. 400.0
El. 350.0
El. 300.0
El. 250.0
El. 200.0
Datum line 200.0 above Sea level
Medina Shale
LAKE ONTARIO
GENERAL DIMENSIONS.
Length Lake to Lake ... 25 miles.
Bottom width ... 200 feet
Width at Water line ... 310 feet
Depth of Canal ... 25 feet
Depth on Lock sills ... 30 feet
Number of Lift locks 7
Guard Lock ... 1
Usable length of Locks ... 820 feet
Usable width ... 79 feet
Height of Lock walls above Sills ... 81.5 feet
Lift of each Lock ... 46.5 feet
Total lift ... 325.5 feet
PROFILE
Scales Horizontal 1" - 1 mile, Vertical 1" - 80 feet
LAKE ERIE
PORT COLBORNE
LOCK 8
Welland Ship Canal
WELLAND
Highway No. 3
Electric Railway
Old Canal Feeder
Chippawa Creek
PORT ROBINSON
ALLANBURG
GUARD GATE
LOCK 7
THOROLD
TWIN LOCKS 6, 5 & 4
LOCK 3
LOCK 2
LOCK 1
ST. CATHARINES
PORT DALHOUSIE
PORT WELLER
Niagara
Decew Falls
Escarpment
Sixteen Mile Creek
Fifteen Mile Creek
Eight Mile Creek
Mean Water level 246.0 ft.
Standard low Water level 243.0
LAKE ONTARIO
THE WELLAND SHIP CANAL
SCALE OF MILES.
0 1/2 1 2 3 4 5 6
PLAN No. 31.

Lock No. 2 and Port Weller Entrance.

THE FIRST WELLAND CANAL

For more than a century a Welland Canal has connected Lake Erie with Lake Ontario, thereby providing one of the principal links in the chain of water transportation extending from Fort William and Port Arthur to the Atlantic Ocean—a distance of over 2,200 miles—the Grain Lane to Europe.

The people of Canada have always attached to the building of the Welland Canal a significance greater than that which usually surrounds an engineering work of such magnitude. This is due not altogether to the tremendous importance of the Welland Canal in the commerce of the Dominion nor to the revenue Canada derives from the constantly increasing production of wheat beyond the Great Lakes, but to the fact that the Falls of Niagara have always been the subject of a peculiar and reverent admiration, and the work of man that overcame the obstacles presented by such an

Port Weller Entrance, April, 1931.

imposing phenomenon of nature, must naturally be surrounded by an atmosphere of importance that would be denied to works with less stupendous setting.

The rapids in the St. Lawrence could be overcome by towing or by comparatively short portages, but the tumbling cataracts of Niagara defied such easy conquest. The 27 miles that separated the waters of Lake Erie from those of Lake Ontario constituted almost insurmountable barriers to water communication between the Upper Lakes and the sea. The construction of an artificial waterway connecting the two lakes thus marked an epoch in the industrial progress of Upper Canada.

It is difficult to state definitely who first proposed the construction of the Welland Canal. It suffices to know that the first step towards the practical solution of the Niagara Falls problem was taken in 1816. At that time Colonel Robert Nichol succeeded in introducing to the

Lock No. 1 at Port Weller.

parliament of Upper Canada a Bill providing funds for a survey of the different water routes between Lake Erie and Lake Ontario and between Lake Ontario and what was then called Lower Canada. But the measure never became law and it remained for the inhabitants of the Niagara district under the inspiration and energetic leadership of the Honourable William Hamilton Merritt to found the Welland Canal Company and build the First Welland Canal as a private enterprise.

On November 30, 1924, there was unveiled at Allanburg, Ontario, a cairn marking the spot where one hundred years before the first sod of the Welland Canal was turned by Mr. George Keefer, President of the Welland Canal Company.

Welland Ship Canal—Entrance Lock at Port Weller.

Twin Locks Nos. 4, 5 and 6 at Thorold, looking North.

The canal traversed the valley of the Twelve Mile Creek from Port Dalhousie on Lake Ontario to Port Robinson on the Chippawa Creek, from which point vessels navigated down the creek to the Niagara River and thence ascended to Lake Erie. It had 39 wooden locks, each 110 feet in length, 22 feet in width, with 8 feet of water on the sills. The summit level—higher than Lake Erie—was supplied by a feeder canal from the Grand River at Dunnville.

This canal was completed in 1829, when two schooners, the *Anne and Jane* of York, Upper Canada (Toronto), and the *R. H. Boughton* of Youngstown, Ohio, were taken through the waterway. By 1833, an extension from Port Robinson to Port Colborne on Lake Erie was completed, but the summit level was still supplied from the Grand River. This route had a length of 27½ miles from lake to lake.

Bridge No. 4—Queenston Road at Homer.

THE SECOND WELLAND CANAL

In 1837 the Government of Upper Canada, which had loaned considerable money to the private company owning the first Welland Canal, converted its loans into stock and in 1841 purchased the entire canal from the private stockholders.

The Government decided at once to enlarge the canal to provide for 9-foot navigation and to complete the St. Lawrence Canals, which were necessary to skirt the several rapids between Lake Ontario and Montreal.

The 39 wooden locks were reduced to 27 by increasing the lifts of each. The new locks were built of cut stone and were each 150 feet long and 26½ feet wide, with 9 feet of water on the sills. The improvement was begun in 1842. It was completed and the canal was opened in 1845. This, together with

Bridge No. 4—Queenston Road at Homer.

the construction of the Port Maitland branch, opened up a new and shorter route to Lake Erie. The section of the canal between the feeder junction (Welland) and Port Colborne was then enlarged for 9-foot navigation and opened for navigation in 1850.

This canal between Thorold and Port Dalhousie remained in operation after the third canal was completed, but since 1915 has been used only for power purposes. In 1853 the navigable depth was increased to 10 feet by raising the banks and the walls of the locks, but it was not until 1881 that the canal was actually fed from Lake Erie at Port Colborne.

The original cost of construction including the first enlargement or the total expenditure prior to Confederation—the 1st July, 1867—was $7,638,239.

Lock No. 3 near Homer, looking South.

THE THIRD WELLAND CANAL

In 1871 a canal commission reporting on general conditions advised the further enlargement of the Welland Canal and it was decided to undertake extensive alterations. Locks were called for 270 feet long, 45 feet wide and having a 12-foot depth of water. This depth of water was later increased to 14 feet, but it was not until 1887 that this depth of water was available throughout the whole canal. Even before this enlargement was completed vessels were being built on the upper lakes too large to pass through the locks.

The Third Welland Canal left Lake Ontario at Port Dalhousie and climbed the Escarpment east of the Second or Old Canal to Allanburg. From Allanburg to Port Colborne it followed the route of the Second Canal. Its structures were the finest example of the stone masonry and its 26 locks

Welland Ship Canal—Bridge at Queenston Road.

Twin Locks No. 4 and Bridge No. 6 at Merritton.

have now joined with those of the Second Canal as mute evidence of the stone-masons' skill.

In 1901 the total tonnage passed through the Welland Canal was 620,209 tons. By 1914 this had increased to 3,860,969 tons, and in 1928, 7,439,617 tons of water-borne freight passed through the Welland Canal on its movement to and from the markets of the world. All of this freight was carried by vessels limited in length to 255 feet and to a breadth not exceeding 44 feet.

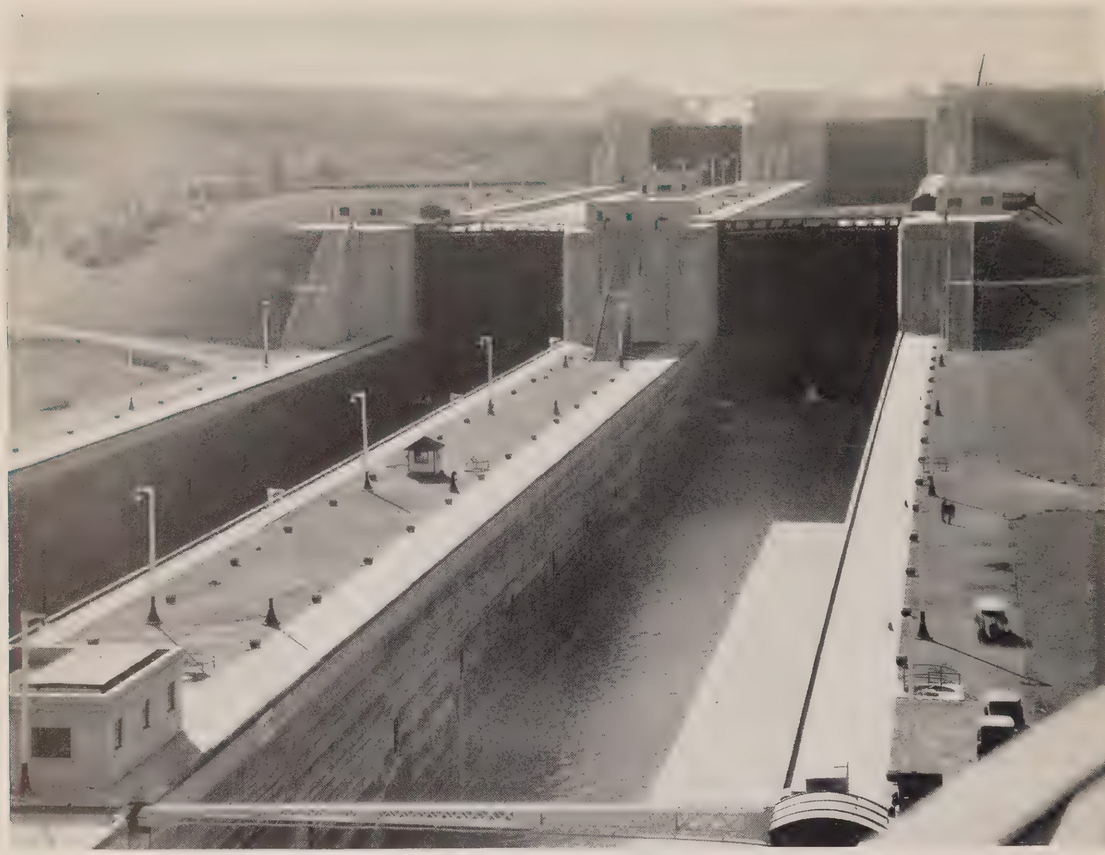
The growth in shipping on the Great Lakes has at all times maintained pace with the demand for water transportation, but this growth has been entirely out of proportion with the navigation facilities provided from Lake Erie to tidewater on the St. Lawrence by way of the Welland and St. Lawrence Canals.

Bridge No. 10, looking North to Guard Gate and Flight Locks.

The tremendous growth of the eastern movement of grain and iron ore and the western movement of coal necessitated the construction of vessels of much larger dimensions than the limiting dimensions of the Welland and St. Lawrence Canals. Already vessels up to 633 feet in length with a beam of 70 feet and a load draught of over 20 feet are in service, but all of these larger vessels have been confined in their movements between the Head of the Lakes and the Harbours of Lake Erie, where transfer of cargo to rail or smaller canal sized vessels became necessary.

THE WELLAND SHIP CANAL

This situation called attention at the beginning of the Twentieth Century to the necessity of many further canal improvements being made



Twin Flight Locks Nos. 4, 5 and 6 at Thorold.

to accommodate the shipping that would use these artificial water channels. The construction of the Fourth Welland Canal as a Ship Canal capable of accommodating the largest of the Great Lakes freighters, as well as large ocean freight carriers, was therefore begun by the Dominion of Canada in 1913.

The route of the Welland Ship Canal departs very radically from that of the previous canals, particularly on the Lower Lake Ontario level of the peninsula. It leaves Lake Ontario at a point about four miles east of Port Dalhousie, the northern terminus of the previous canals, and follows, in practically a straight line, due south along the Valley of the Ten Mile Creek to the foot of the Niagara Escarpment at Thorold. This alignment is maintained in the ascent of the escarpment itself, although the route of the previous canals is followed from the top of the escarpment to Port Colborne in a general

Lock Gates—82 feet high.

Welland Ship Canal—Twin Flight Locks at Thorold.

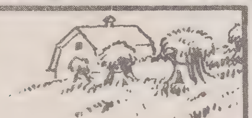
way. All of the sharp bends of the previous canals are eliminated, and it might reasonably be said that the Welland Ship Canal follows a straight north and south course across the peninsula between Lake Erie and Lake Ontario.

As no harbour existed on Lake Ontario at the mouth of the Ten Mile Creek, now the northern terminus of the Welland Ship Canal, an artificial harbour, Port Weller, was one of the necessities of construction. By means of a standard double track railway, extending from Lake Ontario south for seven miles or more along the route of the canal, the surplus excavation of this northern division of the work was disposed of in the form of two embankments projected north from the shoreline into Lake Ontario. At their outer and inner ends these embankments are outlined by reinforced concrete cribs, thus forming a 400-foot wide entrance to the new harbour, one and one-half miles from the original shoreline, and several thousand feet of deep water dockage in the inner end of the harbour. Surplus rock excavation distributed along the exterior of these two embankments preserves them from the erosion of the lake storms.

At extreme low stages the difference in level between Lake Ontario and Lake Erie is 325½ feet and in the Ship Canal this difference in level is overcome by seven locks, each having the same 46½-foot lift. All these locks are of the same dimensions and provide a usable length of 820 feet, a usable width of 79 feet, with 30 feet of water over their sills.

While a minimum of 30 feet of water is provided at all permanent structures, only 20 feet is presently available at low water level in the Upper Lakes harbours and channels, and for the time being the Ship Canal reaches between lock structures are excavated to a minimum 25 feet only. When the future demands of shipping necessitate, this can be increased to 30 feet by the simple process of dredging the reaches for the additional 5-foot depth without interfering in any way with navigation. So, after a period of over one hundred years of canal construction across the Niagara Peninsula, it would appear that a waterway is now provided which is adequate not only to the demands of to-day, but of those that may be made upon it for many years to come.

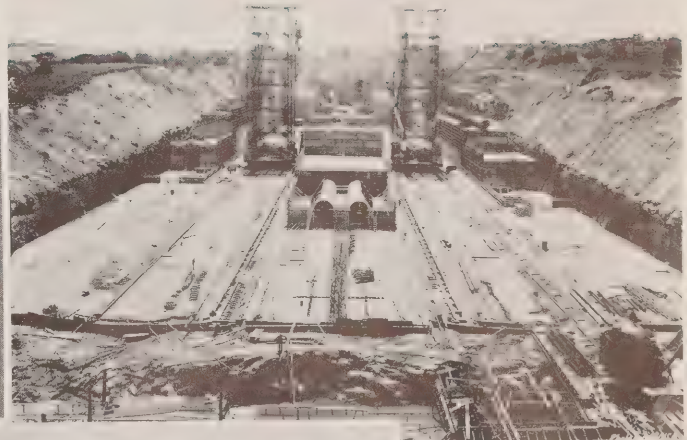
JUNE 1925

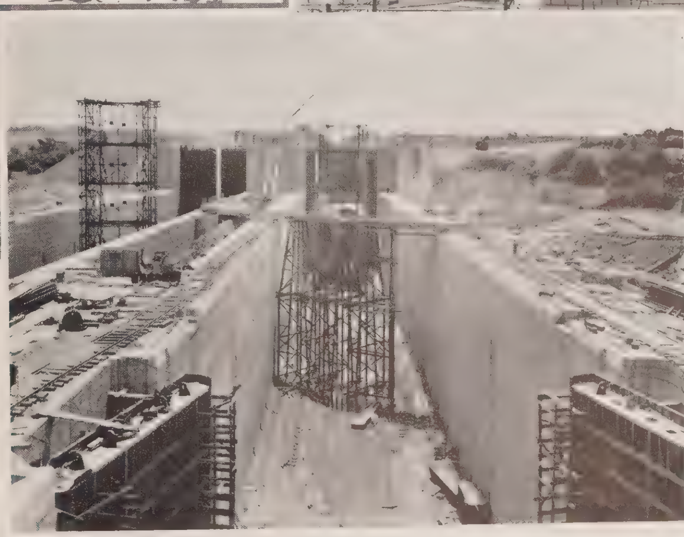


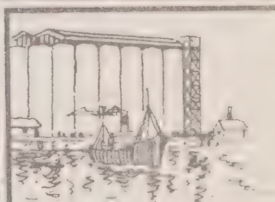
DECEMBER
1925

Flight Locks Nos. 4, 5 and 6—Progress of Construction.

JULY 1926







JULY 1929

Flight Locks Nos. 4, 5 and 6—Progress of Construction.

Lock No. 7 at Thorold.

The first seven miles of the Welland Ship Canal south from Lake Ontario are banked by the slightly rising lower level of the peninsula, which is deservedly called the Garden of Canada because of its natural rolling beauty and intensively cultivated fruit lands. Imposed in this section of the Ship Canal are the first three locks with long straight reaches of canal prism of over 200 feet bottom width and 310 feet width at water level, providing ample accommodation for the movement and passage of up and downbound navigation. These three locks elevate navigation 139½ feet above the Lake Ontario level and bring it to the foot of the Niagara Escarpment.

The climb up the face of the escarpment, by means of four locks of equal lifts, is obtained without any deviation from the direct route. Three of these locks are superimposed immediately one above the other, so that in a distance

The construction of the WELLAND SHIP CANAL, started in 1913, was carried out by the **Government of the Dominion of Canada,** under the **Ministries** of:

The Rt. Hon. R. B. Bennett	Since 1930
" " W. L. Mackenzie King	1926–1930; 1921–1926
" " Arthur Meighen	1926; 1920–1921
" " Sir R. L. Borden	1911–1920

Department of Railways and Canals

Ministers	Hon. Dr. R. J. Manion	Since 1930
	" T. A. Crerar	1929–1930
	" C. A. Dunning	1926–1929
	" W. A. Black	1926
	Rt. Hon. G. P. Graham	1923–1926
	Hon. Wm. C. Kennedy	1921–1923
	" J. A. Stewart	1921
	" Dr. J. D. Reid	1917–1921
	" Frank Cochrane	1911–1917
Deputy Ministers	V. I. Smart	Since 1930
	R. A. C. Henry	1929–1930
	G. A. Bell	1918–1929
	A. W. Campbell	1910–1918
Chief Engineers	Col. A. E. Dubuc	Since 1924
	W. A. Bowden	1910–1924
Asst. Chief Engineer	L. Sherwood	Since 1911

Welland Ship Canal—Field Engineering Staff

Engineers in Charge	A. J. Grant	Since 1919
	J. L. Weller	1912–1917
Principal Assistant Engineers	E. G. Cameron	Since 1924
	W. H. Sullivan	1913–1923
Designing Engineer	F. E. Sterns	Since 1913
Bridge Engineers	M. B. Atkinson	Since 1921
	H. F. V. Estrup	1913–1917
Mechanical Engineer	J. B. McAndrew	Since 1919
Electric Engineer	A. L. Mudge	Since 1927
Division Engineers	J. J. Aldred	1913–1917
	H. M. Belfour	1913–1917
	E. G. Cameron	1914–1918
	C. L. Hays	1913–1917
	F. C. Jewett	1919–1930
	E. P. Johnson	Since 1919
	George Kydd	1924–1927
	F. S. Lazier	1919–1925
	E. P. Murphy	Since 1927
	C. W. West	Since 1925

Consulting Engineers:

Bridges	Harrington, Howard and Ash.
	Scherzer Rolling Lift Bridge Company.
	C. N. Monsarrat.
Gate Lifter	Canadian Wellman-Seaver-Morgan Company, Limited.

WELLAND SHIP CANAL MAIN CONTRACTORS

Sections Nos. 1 to 8

Atlas Construction Company, Limited, and E. O. Leahey and Company, Limited.
Baldry, Yerburgh & Hutchinson, Limited.
Canadian Dredging Company, Limited.
Doheny, Quinlan and Robertson.
Dominion Dredging Company, Limited.
P. Lyall and Sons Construction Company, Limited.
Maguire and Cameron.
O'Brien and Doheny, Quinlan and Robertson.
Johnston P. Porter.
A. W. Robertson, Limited.

Gate Yard

T. A. Brown Company, Limited.

Steel Gates

Steel Gates Company, Limited.

Lock Machinery, Lock Fenders and Capstans

Canadian Vickers, Limited.
Dominion Bridge Company, Limited.
Montreal Locomotive Works, Limited.

Unwatering Equipment

Goldie and McCulloch, Limited.
John Inglis Company, Limited.

Bridges

Canadian Bridge Company, Limited.
Dominion Bridge Company, Limited.
Hamilton Bridge Company, Limited.

Power House

Substructure—Aiken, Inness and MacLachlan, Limited.
Turbines—S. Morgan-Smith-Inglis Company, Limited.
Generators—Canadian General Electric Company, Limited.
Surge Tank—Horton Steel Works, Limited.

Electrical Equipment

Canadian General Electric Company, Limited.
Canadian Westinghouse Company, Limited.
Cutler-Hammer Company.
English Electric Company of Canada, Limited.
Ferranti Electric, Limited.
Harland Engineering Company.
Maloney Electric Company, Limited.
Northern Electric Company, Limited.
Packard Electric Company, Limited.

Cement

Canada Cement Company, Limited.

Sand

National Sand and Material Company, Limited.

Gate Lifter

Collingwood Shipyards, Limited.

Third Welland and Welland Ship Canals at Thorold.

Lock No. 7 at Thorold.

of slightly over one-half mile, navigation is elevated another 139½ feet. This arrangement, however, of three locks in flight necessitates the duplication of these locks to provide separate means of passage for up and downbound navigation, where, with but one flight of locks, a serious delay to the passage of navigation would occur.

With a short intervening stretch of canal prism, the last of the seven locks, which brings navigation to Lake Erie level, is reached in the Town of Thorold, but this intervening short reach provides water space for vessels to pass and eliminates, for the present at least, the necessity of a duplicate lock again at this point.

From the head of Lock 7 at Thorold across the remainder of the peninsula to Port Colborne the Ship Canal provides the same standard

Bridge No. 9, Guard Gate and Weir.

width of waterway as elsewhere, with 200 feet bottom width and a minimum 25-foot depth. Spanning this waterway at intervals are the swing, bascule and vertical lift bridges which accommodate the numerous railway and highway traffic arteries which cross the peninsula from east to west. The vertical lift bridges, operating on the principle of the counter-balanced elevator, provide for the movable span being lifted 120 feet clear of the waterway for the passage of navigation, and offer a much less restricted channel than is provided by the use of the swing-bridge so common to navigation waterways.

On Lake Erie, being a vast expanse of shoal water, the water level is subject to rapid variations caused by wind direction, and differences in level as great as 11 feet have been observed at Port Colborne—the result of a

Weir, Guard Gate and Bridge No. 9.

change in wind direction from the east to the west. Such a variation, transferred to the summit level of the canal, would introduce tremendous and expensive traffic delays and so tend to defeat the purpose for which the improved waterway is provided. Consequently at Port Colborne, immediately before the canal joins up with the lake, a guard lock is provided through which navigation is passed from the regulated summit level to the variable level prevailing on the lake. This lock is 1,380 feet long, has the same standard width and draught, but its lift is that determined from day to day by Lake Erie itself.

Midway across the peninsula the summit level of the canal crosses the Chippawa Creek (Welland River) a sluggish stream having its source in the western part of the peninsula and flowing in an easterly direction to discharge into the Niagara River at the head of the rapids above the Falls. The summer level of the river being some six feet below that of the summit level of the

Summit Level, looking North to Thorold.

canal necessitated the construction of an under-passage, by which its waters are carried entirely under the Ship Canal. The foundations of this structure, an inverted syphon culvert, stand at a depth of 86 feet below the level of the water in the canal, and six tubes, each 22 feet in diameter, form the water passage by which Chippawa Creek flows on to the Niagara River.

Construction and Equipment

Actual construction of the Welland Ship Canal was started in the fall of 1913, at which time the lock division of the new waterway from Lake Ontario to Thorold was placed under contract and vigorous construction activities on this portion of the work were continued in spite of the outbreak of the World War in 1914. In the spring of 1916, with the ever-increasing

Summit Level and Chippawa Creek North from Port Robinson.

shortage of material and man power for the further continuance of this work, construction had to be suspended and remained so until 1919.

As a means of re-establishing in peace-time pursuits the many men returning from overseas service in the World War, construction on the canal was resumed in 1919 on a cost-plus basis by the original contractors, but as this failed to obtain the desired object the cost-plus basis of carrying on the work was abandoned. The remainder of the work was all placed under contract, the divisions of the work on the summit level being placed under construction at this time, in order to synchronize the completion of all sections.

The peak of activities was reached in 1927, when, with the northern end of the work still under active construction, work was being carried on as well

The Chippawa Creek and Syphon Culvert at Welland.

throughout the whole extent of the canal from lake to lake, and during this construction season a force of nearly four thousand workmen was engaged throughout the extent of the canal zone.

With the advance of the general construction contracts, it became possible to proceed with the manufacture and installation of the operating equipment of the structures. Then followed the fabrication and erection of the steel gates. Thirty gate leaves, each over 82 feet high by 48 feet long and 5 feet thick, each leaf weighing complete nearly 500 tons, were required for the lower gates of the seven locks between Lake Ontario and Thorold, where, as well, and including those for the gate yard, twenty-two upper gates, 35½ feet high, 48 feet long and each weighing about 200 tons were also required. In addition, 12 gates of an intermediate size, 44½ feet high, 48 feet

Summit Level, North from Bridge No. 14 at Welland.

long, also of all steel construction, were provided for the gates of the guard lock at Port Colborne and the guard gate structure immediately south of Lock 7 in Thorold.

For the handling and replacement of these gates is provided a floating pontoon gate lifter, capable of lifting and placing in position any leaf up to one million pounds weight. As well, on the east side of the canal at the upper entrance of Lock 1, immediately above the Lake Ontario level, is provided a gate repair basin. This, in itself, is a drydock which is filled and emptied by gravity. Here eight spare gate leaves are stored, and it provides as well a drydock for repairing damaged gate leaves and wintering the gate lifter.

For the operation of the gates and valves of the various lock structures, electrically operated machinery is provided and as electricity is the source

Summit Level, North from Bridge No. 18 at Dainville.

of power used throughout the canal for all operations, a 15,000 K.V.A. electrical development has been built at the foot of the flight locks using the 186-foot head immediately available at this point between the upper pool level of Lock 7 and the lower pool level of Lock 4, where this power house is situated. Approximately 10,000 horse-power of electric energy is required for the lighting and the operation of the locks, weirs and bridges on the Welland Ship Canal.

In one marked respect the construction of the Welland Ship Canal differs vastly from the three previous canals. Realizing, during construction, that this enlarged waterway would require, in operation, a greater measure of protection against the erosive agents of nature, and one of the greatest

Bridges Nos. 18 and 17, Summit Level North from Dainville.

sources of delay to the navigation of limited artificial waterways, that of cross winds, an extensive reforestation program has been carried on with construction. Vast numbers of trees, native to the district, have been developed from seed, and these are now fast maturing into trees; the roots of which will bind together the earth embankments of the prism reaches. The branches and leaves will form a wind-break by the aid of which navigation will pass during any mood of the winds.

So, while in construction, an ugly gash was made in the landscape of the Garden of Canada from Lake to Lake, this, with the assistance of mother nature, is now rapidly healing, and what might have been a gaunt commercial waterway is being transformed into a zone of natural scenic beauty.

Guard Lock at Humberstone.

General Features of the Welland Ship Canal

Alignment—Practically a straight line north to south, with Port Weller at the Lake Ontario end and Port Colborne at the Lake Erie end.

Length lake shore to lake shore - - -	25 statute miles.
Length between outer works of Port Colborne and Port Weller Harbours - - -	27·7 statute miles.
Width of canal prism at 25 foot depth -	200 feet.
Width of canal prism at water line - -	310 feet.
Side slopes of canal prism - - - -	2 horizontal to 1 vertical and 3 horizontal to 1 vertical.
Depth of canal prism - - - - -	25 feet with certain sections, including harbour terminals, excavated to 27½ feet.

Upper Entrance to Guard Lock at Humberstone.

Difference in level between extreme low water levels of Lake Ontario and Lake Erie	325½ feet.	
Number of locks, including Guard Lock at Humberstone	8.	

Flight Locks 4, 5 and 6 at Thorold are all twin in order to not delay transit.

Length Guard Lock, between inner gates	1,380	feet.
Length of lift locks, between inner gates	859	"
Usable length of lift locks	820	"
Width of all locks	80	"
Depth of water over sills of locks	30	"
Lift of all locks, except Guard Lock	46½	"
Time required to fill lock	8	minutes.

Fort Colborne Inner Harbour and Guard Lock.

Normal time for vessel to traverse the Ship Canal	7½ hours.
Number of railway and highway bridges across the Ship Canal	20
Minimum overhead clearance of vertical lift bridges	120 feet.
Connected motor load of Ship Canal, including Port Colborne Elevator	15,300 h.p.
Total rock excavation	9,183,000 cu. yds.
Total earth excavation	52,409,000 "
Total watertight embankments	4,922,000 "
Total concrete, all classes	3,614,000 "
Total reinforcing steel	36,975,000 lbs.
Total steel sheet piling	55,365,000 "
Total weight of metal in lock gates with fixed parts and machinery	48,000,000 "
Total weight of metal in valves of locks and weirs, with machinery	9,800,000 "
Total capital cost, approximately	$130,000,000
Employees required for operating Ship Canal, including Head Office organization and Stores Department	300

Welland Ship Canal—Bridges at Port Colborne.

Other Notable Features of the Welland Ship Canal

The Humberstone Guard Lock, 1,380 feet between hollow quoins of inner gates, is the longest lock in the world.

The lift of 46½ feet of each of the main locks of the Ship Canal is the highest of any existing lock of the mitre gate type.

Each of the main filling and emptying culverts of the lift locks has an area of 210 square feet and could easily accommodate the largest motor passenger bus on the highways.

The lock wall between twin Locks 4 and 5 is over 130 feet high, or about the height of a ten-story building.

Water for lockage at Flight Locks 4, 5 and 6 is supplied from a basin formed by the construction of an embankment 3,500 feet long and having a maximum height of 80½ feet. The basin has an area of 84 acres.

The six 22-foot syphon tubes carrying the Chippawa Creek under the Ship Canal at Welland are each large enough to accommodate the largest railway locomotive at present in service. The spring freshet flow of Chippawa Creek at this point has been as high as 28,800,000 cubic feet per hour.

The Port Colborne Breakwater extension, 2,000 feet long, was formed by sinking reinforced concrete cribs on a prepared bottom and covering them with a heavy concrete superstructure. The extension was further protected by a heavy rock embankment dumped on the southwest side. The reinforced concrete cribs are 100 feet long, 50 feet wide and vary from 18 to 31 feet deep; they were constructed at Port Maitland, about 20 miles west of Port Colborne, towed to the site and sunk by opening valves in the bottom. When sunk in the desired position, rockfilling followed immediately.

Features Contributing to the Safety of the Various Structures on the Welland Ship Canal

1. All steel service gates of the locks are provided with Gowan safety castings which permit any gate being opened at the mitre to the extent of four feet without becoming unshipped. This feature is expected to eliminate

Port Colborne Outer Harbour.

a great many accidents of the type which have occurred on the Third Welland Canal and the St. Lawrence Canals by reason of vessels getting out of control in the locks and ramming the gates.

2. Further protection of the upper gates from upbound vessels is provided by heavy concrete breast walls at the upper end of each lift lock. The upper gates of each lift being superimposed on the breast wall, an upbound vessel entering a lift lock at the lower level cannot, under any circumstances, ram the upper gates.

3. Additional protection to the gates is provided by wire rope fenders installed immediately above and below each lower gate and above each upper gate where no bridge crosses the upper entrance. A fender consists in the main of a heavy 3½-inch diameter wire rope placed horizontally across

the lock chamber at coping level, some 70 feet above or below the gate it is intended to protect and is so secured that any vessel out of control must break it before reaching the gate itself. This rope is placed across or removed from the lock chamber by a structural steel arm located on the lock wall and operated from a vertical to a horizontal position or vice versa by a bascule movement.

4. All equipment controlling the machinery operating the valves, gates, fenders and signals at a lock is so electrically interlocked that the operator can only conduct the lockage of a vessel in a definite order of operations. This arrangement not only protects the equipment of the locks, but prevents disasters consequent upon the operation of lock gates or valves in other than the predetermined order. Similarly the introduction of limit switches on all lock and bridge machinery protects the equipment from careless operation.

5. In the event of any lock gates being carried away by a vessel navigating the canal, hydraulic turbines automatically operating the control valves in the regulating weirs at the different locks will prevent the flooding of lands and property adjacent to the canal prism.

6. A Guard Gate and Safety Weir have been constructed about three-quarters of a mile above Lock No. 7 in order that the water of the summit level of the canal (15½ miles long) will not flood the country north of Thorold in the event of the gates of Lock No. 7 being carried away. The operation of the Guard Gate is so interlocked electrically with the operation of the upper gates of Lock No. 7 that the Guard Gate and the upper gates of Lock No. 7 cannot be opened simultaneously.

7. The territory adjacent to the summit level of the canal is protected from the waters of Lake Erie by the Guard Lock and Supply Weir at Humberstone.

8. In the event of the electric power supply for the canal being suddenly shut off, gasolene engines installed at all bascule and vertical lift bridges and operating independently of the electric motors will carry out the necessary movements of these bridges.

Gate Lifter handling Gate Leaf 82 feet high.

Port Colborne Entrance and Harbour looking North.

Old Welland Canal at Thorold

THE FOUR WELLAND CANALS
DIAGRAMMATIC COMPARISONS

FIRST WELLAND CANAL
STARTED 1824 —— COMPLETED 1829

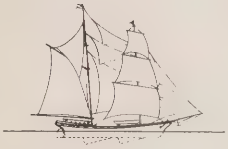
TYPICAL VESSEL

LENGTH 100 FT – CARGO CAPACITY 165 TONS

TYPICAL LOCK

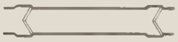
LENGTH BETWEEN GATES .... 110 FT.
WIDTH OF LOCK .... 22 FT.
DEPTH OF WATER OVER SILLS .... 8 FT.
SINGLE LIFTS .... 6 FT. TO 11 FT.
NUMBER OF LOCKS 39

SECOND WELLAND CANAL
STARTED 1842 —— COMPLETED 1845



TYPICAL VESSEL

LENGTH 140 FT – CARGO CAPACITY 750 TONS



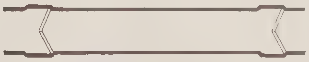
TYPICAL LOCK

LENGTH BETWEEN GATES .... 150 FT.
WIDTH OF LOCK .... 26 FT. 6 IN.
DEPTH OF WATER OVER SILLS .... 9 FT.
SINGLE LIFTS .... 9 FT. 6 IN. TO 14 FT. 3 IN.
NUMBER OF LOCKS 27

THIRD WELLAND CANAL
STARTED 1875 —— COMPLETED 1887

TYPICAL VESSEL

LENGTH 255 FT – CARGO CAPACITY 2700 TONS



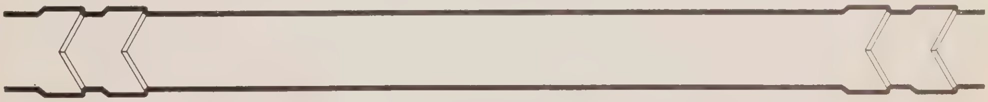
TYPICAL LOCK

LENGTH BETWEEN GATES .... 270 FT.
WIDTH OF LOCK .... 45 FT.
DEPTH OF WATER OVER SILLS .... 14 FT.
SINGLE LIFTS .... 12 FT. TO 16 FT.
NUMBER OF LOCKS 26

WELLAND SHIP CANAL
STARTED 1913 —— COMPLETED 1932–33

LENGTH BETWEEN INNER GATES .... 859 FT
WIDTH OF LOCK .... 80 FT
DEPTH OF WATER OVER SILLS .... 30 FT. (REACHES 25 FT.)
SINGLE LIFTS .... 46 FT. 6 IN.
NUMBER OF LOCKS – INCLUDING 3 TWIN 8
TOTAL LOCKAGE .... 325 FT. 6 IN.

THE GUARD LOCK AT HUMBERSTONE IS 1380 FT LONG BETWEEN INNER GATES



TYPICAL LOCK

TYPICAL VESSEL

MAXIMUM LENGTH 820 FT. & CARGO CAPACITY 25000 TONS AT 24 FT. DRAFT.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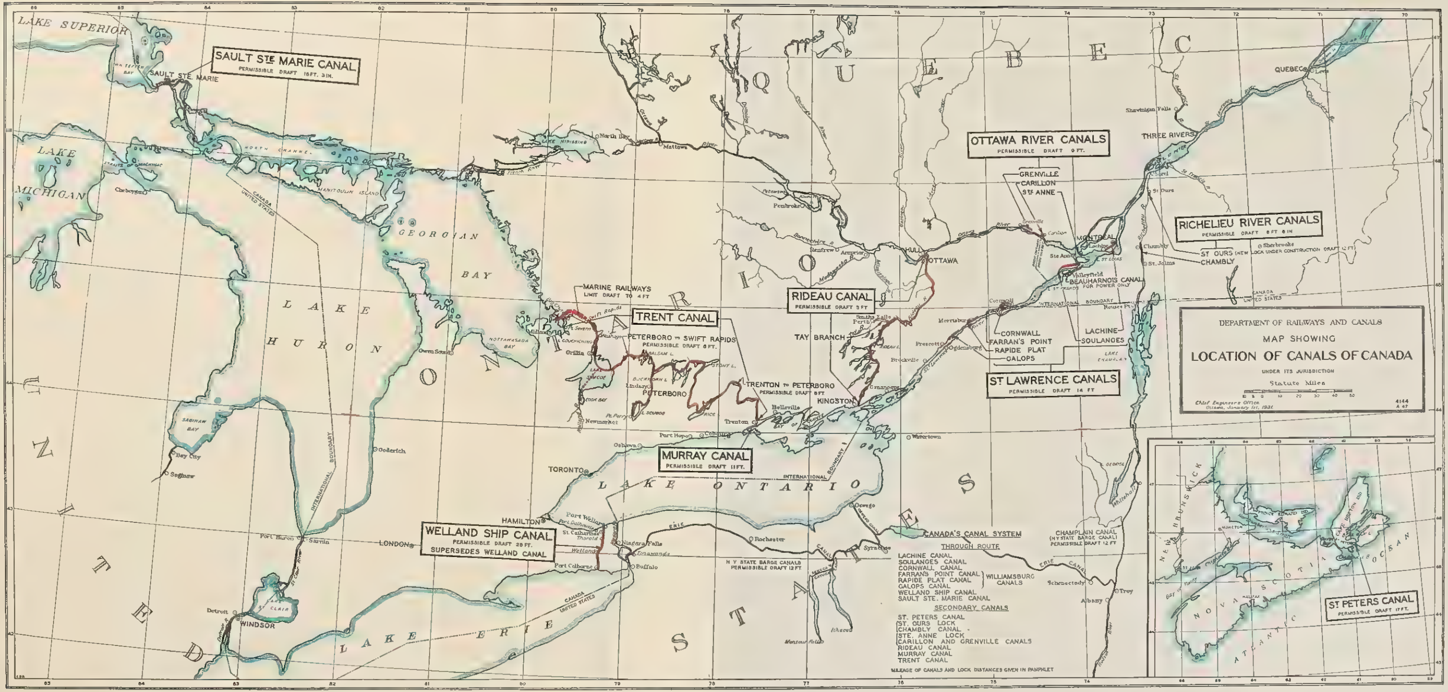
DEPARTMENT OF RAILWAYS AND CANALS
MAP SHOWING
LOCATION OF CANALS OF CANADA
UNDER ITS JURISDICTION
Statute Miles
Chief Engineer's Office
Ottawa, January 1st, 1931.
SAULT STE MARIE CANAL
PERMISSIBLE DRAFT 18FT. 3IN.
OTTAWA RIVER CANALS
PERMISSIBLE DRAFT 9 FT.
GRENVILLE
CARILLON
STE ANNE
RICHELIEU RIVER CANALS
PERMISSIBLE DRAFT 8 FT 6 IN
ST OURS (NEW LOCK UNDER CONSTRUCTION DRAFT 12 FT)
CHAMBLY
BEAUHARNOIS CANAL
FOR POWER ONLY
MARINE RAILWAYS
LIMIT DRAFT TO 4 FT
TRENT CANAL
PETERBORO TO SWIFT RAPIDS
PERMISSIBLE DRAFT 6 FT.
TRENTON TO PETERBORO
PERMISSIBLE DRAFT 6 FT
RIDEAU CANAL
PERMISSIBLE DRAFT 5 FT
TAY BRANCH
CORNWALL
FARRAN'S POINT
RAPIDE PLAT
GALOPS
LACHINE
SOULANGES
ST LAWRENCE CANALS
PERMISSIBLE DRAFT 14 FT
MURRAY CANAL
PERMISSIBLE DRAFT 11FT.
WELLAND SHIP CANAL
PERMISSIBLE DRAFT 25 FT.
SUPERSEDES WELLAND CANAL
N Y STATE BARGE CANALS
PERMISSIBLE DRAFT 12 FT
CHAMPLAIN CANAL
(N Y STATE BARGE CANAL)
PERMISSIBLE DRAFT 12 FT
ST PETERS CANAL
PERMISSIBLE DRAFT 17 FT.
CANADA'S CANAL SYSTEM
THROUGH ROUTE
LACHINE CANAL
SOULANGES CANAL
CORNWALL CANAL
FARRANS POINT CANAL
RAPIDE PLAT CANAL
GALOPS CANAL
WILLIAMSBURG CANALS
WELLAND SHIP CANAL
SAULT STE. MARIE CANAL
SECONDARY CANALS
ST. PETERS CANAL
ST. OURS LOCK
CHAMBLY CANAL
STE. ANNE LOCK
CARILLON AND GRENVILLE CANALS
RIDEAU CANAL
MURRAY CANAL
TRENT CANAL
MILEAGE OF CANALS AND LOCK DISTANCES GIVEN IN PAMPHLET
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
GEORGIAN BAY
LAKE ONTARIO
LAKE ERIE
Q U E B E C
O N T A R I O
U N I T E D S T A T E S
NOVA SCOTIA
NEW BRUNSWICK
ATLANTIC OCEAN
INTERNATIONAL BOUNDARY
CANADA
UNITED STATES
SAULT STE. MARIE
North Bay
Mattawa
Pembroke
Renfrew
Arnprior
HULL
OTTAWA
MONTREAL
Lachine
Valleyfield
QUEBEC
Levis
THREE RIVERS
Shawinigan Falls
Sorel
St. Ours
Chambly
St. Johns
Sherbrooke
Cornwall
Morrisburg
Prescott
Ogdensburg
Brockville
Smiths Falls
Perth
KINGSTON
Belleville
Trenton
Cobourg
Port Hope
Oshawa
TORONTO
Newmarket
Lindsay
PETERBORO
Orillia
Midland
Owen Sound
Goderich
HAMILTON
Port Weller
Port Dalhousie
St. Catharines
Thorold
Welland
Port Colborne
Niagara Falls
Buffalo
Tonawanda
LONDON
Port Huron
Sarnia
Detroit
WINDSOR
Bay City
Saginaw
Cheboygan
Rochester
Oswego
Syracuse
Ithaca
Montour Falls
Watertown
Schenectady
Albany
Troy
Whitehall
Rouses Pt.
MANITOULIN ISLAND
NORTH CHANNEL
SAGINAW BAY
NOTTAWASAGA BAY
LAKE NIPISSING
LAKE CHAMPLAIN
LAKE ST. CLAIR

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